PB85-237113

Hexachlorobenzene in Selected Marine Samples An Environmental Perspective

(U.S.) Environmental Research Lab.
Narragansett, RI

Jul 85

U.S. Department of Commerce
National Technical Information Service
NTIS

PB85-237113

EPA/600/D-85/139
July 1985

HEXACHLOROBENZENE IN SELECTED MARINE SAMPLES

AN ENVIRONMENTAL PERSPECTIVE

Donald K. Phelps, Richard J. Pruell[1] and James L. Lake

United States Environmental Protection Agency
Environmental Research Laboratory
Narragansett, Rhode Island
02882

[1] Science Applications International Corporation
C/O U.S. Environmental Protection Agency
Environmental Research Laboratory
Narragansett, R.I. 02882

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
NARRAGANSETT, RI 02882

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA/600/D-85/139		PB85 237113/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
HEXACHLOROBENZENE IN SELECTED MARINE SAMPLES: AN ENVIRONMENTAL PERSPECTIVE	July 1985
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
D.K. Phelps, R.J. Pruell and J.L. Lake	ERLN-738
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
U.S.EPA, ERL-Narragansett South Ferry Road Narragansett	AARB1A
	11. CONTRACT/GRANT NO.
	NA
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Same As Above	Symposium Proceedings
	14. SPONSORING AGENCY CODE
	EPA/600/05

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Hexachlorobenzene (HCB) was designated as a chemical of interest. A new sample of mussel homogenate was spiked with an authentic HCB standard. Recovery of the spike was 56%. Re-examination of previously analyzed GC chromatograms and archived samples revealed peaks that co-eluted with the authentic HCB standard. Levels of HCB were at least three to four orders of magnitude lower than PCBs; two orders of magnitude lower than pyrene; and one to two orders of magnitude lower than either phenanthrene or benzo(a)pyrene found in the same mussel samples. Gas chromatograms (EC detection) of seawater (dissolved and particulate phases) and sediments also reveal very low levels of HCB. Because GCMS results indicated that levels of HCB were below the level of detection, it was not possible to verify the presence of HCB using GCMS.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
DISTRIBUTE TO PUBLIC	UNCLASSIFIED	29
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	$8.50

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

SUMMARY

Hexachlorobenzene (HCB) was designated as a chemical of interest. A new sample of mussel homogenate was spiked with an authentic HCB standard. Recovery of the spike was 56%. Re-examination of previously analyzed GC chromatograms and archived samples revealed peaks that co-eluted with the authentic HCB standard. Levels of HCB were below 1 ng/g in all samples that were re-examined. HCB levels were at least three to four orders of magnitude lower than PCBs; two orders of magnitude lower than pyrene; and one to two orders of magnitude lower than either phenanthrene or benzo(a)pyrene found in the same mussel samples. Chromatograms of seawater (dissolved and particulate phases) and sediments also reveal very low levels of HCB. Because GCMS results indicated that levels of HCB were below the level of detection it was not possible to verify the presence of HCB.

The environmental perspective on HCB provided through the utilization of existing U.S. Mussel Watch data, demonstrates levels of HCB in mussels are minor compared with other organic compounds such as PCBs, and PAHs (phenanthrene, pyrene, and benzo(a)pyrene). Mussels were deployed in areas impacted by industrial activity; disposal of sewage sludge; disposal of dredged materials and relatively clean reference sites. The mussel was used as a monitor of the marine food chain; a surrogate for other biota present in the areas of collection and a sentinel organism to monitor localized differences in biologically available chemical compounds.

The degree of environmental threat posed by HCB in the marine environment, as seen through the window provided by Mussel Watch data

appears to be relatively low. On this basis it is recommended that a decision be made not to pursue an expanded monitoring program for HCB in the marine environment solely for the purpose of collecting more data on this compound.

INTRODUCTION

There are two purposes to be accomplished in this paper. The first is to develop a marine environmental perspective provided by the U.S. Mussel Watch program. The second is to demonstrate the proactive use of the existing Mussel Watch data base and archives to provide a first order assessment of the relative risk associated with the distribution of hexachlorobenzene (HCB) in the marine environment.

The Environmental Perspective Provided by The U.S. Mussel Watch Program

The first purpose of the paper is to elucidate a marine environmental perspective offered by the U.S. Mussel Watch program. The Mussel Watch data base provides a meaningful environmental perspective by which relative risks, resulting from distributions of chemical compounds such as HCB, may be viewed in the marine coastal environment. This perspective may include comparisons of a variety of concentrations of organic toxicants to determine relative levels found in the mussel. It may be used also to demonstrate occurrence of the compound in relation to specific types of effluent discharges, or the general pattern of distribution of the chemical on an extensive geographic scale which includes highly

impacted as well as relatively clean sites. The U.S. Mussel Watch program is reviewed in the following paragraphs in order to elucidate the nature and importance of the environmental perspective it provides.

The primary goal of the U.S. Mussel Watch program, sponsored by the U.S. Environmental Protection Agency (EPA), is to examine the utility of "sentinel organisms" to monitor the environmental quality of coastal waters. Spatial and temporal trends of selected chemical compounds were measured over a three year time period between 1976-1978. Mytilus sp. were chosen as the primary sentinel organism because of their ubiquitous distribution, extensive consumption by man, and the fact that they integrate contaminants over time. The presence of chemical compounds as tissue residues within the animals also indicates that those compounds are available biologically. Complete rationales for choosing filter feeding bivalves, the sampling sites, and methodologies for sample collections and chemical analyses are discussed in detail in Goldberg et al., 1978, and Farrington et al., 1983.

The Ecological Role of Filter Feeding Bivalves

From an ecological perspective, mussels can be classified as planktivores and detritivores. As such, they assimilate primary production and detritus, and package them for consumption by predators. Man is one of the top predators of Mytilus edulis. In the process of procurring food, mussels filter large volumes of water, that include a considerable range in size and type of suspended particulates. They may accumulate

chemical compounds through two basic pathways; 1) as solutes dissolved in the water column that then enter the animal through gill surfaces during filtration of water and, 2) through materials associated with suspended particulates that are ingested directly by the animals (Figure 1). In polluted areas they function as direct or indirect conduits for contaminants from the water column, suspended paticulates, and sediments to higher marine trophic levels and eventually to humans (Figure 2).

The Mussel as a Surrogate for Other Biota

The marine ecosystem is characterized by persistent communities and a physically mixed system that is a conservative homogeneous aqueous media in nature. There is a high level of integration within the biological component of the system as well as between the biological and physical components. All marine biota use the aquatic media to feed, respire, reproduce and to rid themselves of metabolites and other waste products. In a broad sense, all biota within a given area are exposed to a very similar media. The qualitative composition of chemical compounds found as tissue residues in a variety of marine biota collected from within any given area may be expected to be similar. The mussel, or a variety of other members of a given marine community, may represent a reasonable surrogate for other members of that community in this broad sense.

Summary of U.S. Mussel Watch Results

Chemical Residues

Chemical analyses conducted in support of the original U.S. Mussel Watch program were limited of necessity. Six heavy metals, previously identified as pollutants in coastal environments, were chosen; lead (Pb), cadmium (Cd), silver (Ag), zinc (Zn), copper (Cu), and nickel (Ni). Radionuclide analyses were limited to Pu-239+240, Pu-238, Am-241, and Cs-137. Representatives from two sets of high-molecular-weight halogenated hydrocarbons were included as well; DDT, p,p'-DDE, p,p'-DDD and polychlorinated biphenyls (PCBs) analyzed according to their principal contaminant forms '1254' and '1260'. A suite of hydrocarbons, completed the compounds chosen for analyses. These compounds included saturated hydrocarbons, aromatic hydrocarbons, and some sulphur-containing compounds. (Goldberg, 1978).

Pb, Cd, and PCBs were chosen for detailed discussion in Farrington et al., 1983. This summary will be limited to those compounds as well. High lead concentrations in urbanized areas of the U.S. east and west coasts are demonstrated (Figure 3) (Farrington et al., 1983). Elevated levels of cadmium on the west coast are related to upwelling of mid-depth Pacific waters (Figure 4); however, collections from some east coast stations located in proximity to urbanized/industrialized areas are also somewhat elevated. Whether these are natural or anthropogenic phenomena cannot be discerned from the available data (Farrington et al.,

1983). PCB concentrations are low in areas remote from urban centers while highest concentrations are found in animals living near urban centers (Figure 5). There is a northeast megalopolis effect with elevated PCB concentrations in samples from the Chesapeake Bay, Maryland, to Cape Ann, Massachussets (Farrington et al., 1983). The distributional patterns of tissue chemical residues for Pb, Cd, Ag, Zn, Cu, Ni, and PCB,in mussels and oysters for both the coasts repeats each year 1976, 1977, and 1978 (Farrington et al., 1983).

Biological Effects

Biological effects measures developed and evaluatd for the U.S. Mussel Watch Program include diverse biological levels of organization; subcellular, cellular, tissue, organ, whole animal, population, and community (Figure 6). These measures and evaluations of their application are described in detail in Phelps et al. (1985). The current emphasis within the program is at the subcellular, whole animal, and population levels of organization. Genetically active substances within cells, energy available for production in individuals (scope for growth), and the analysis of population dynamics from the growth, fecundity and mortality of individuals represent on-going studies within the biological effects portion of the U.S. Mussel Watch program.

Possible relationships between chemical residues and pathologies in animals collected for the U.S. Mussel Watch (Goldberg et al., 1978) program have been reported by Yevich and Barszcz (1983) and Reynolds et al. (1981). Two stations, one each from a highly urbanized area on the west coast (San Francisco, Cal.) and the east coast (Manhasset Neck, Long Island, N.Y.) produced animals having possible hematopoietic

tumors. In total, 106 stations were visited. There was a trend noted between high levels of PCB and heavy parasitic infestation. However, in spite of a variety of other pathologies recorded in the studies, there was no consistent statistical relationship that could be established between pathologies and levels of metals or organics found in the sentinel organisms.

Proactive Use of U.S. Mussel Watch Data and Archives

The second purpose of this paper is to examine the presence of HCB in the marine environment through the proactive use of existing U.S. Mussel Watch data and archived materials (Figure 7). The approach, based upon the assumption that HCB would be seen through the same 'chemical window' as PCBs, consists of five steps:

I. Select. Selection of a chemical compound of interest, such as HCB, initiates the process.

II. Re-Examine. Existing GC, GCMS chromatograms and archived extracts (frozen for storage) are re-examined. Also the method is checked for recovery.

III. Analyze. A new sample may be prepared and analyzed.

IV. Compare. Quantitative comparisons are made between levels of the chemical of interest (HCB) and compounds previously analyzed (PCBs, PAHs). Relative degrees of toxicity (carcinogenicity) are considered.

V. Decisions. Decisions, based on the relative degree of environmental threat posed by the chemical of interest (i.e., HCB) are made;

1) to pursue monitoring (open up all existing archives, initiate new collections), or 2) to stop and reserve resources for compounds found to be of higher environmental concern (priority).

CHEMICAL METHODS

Mussel samples were homogenized using a polytron with teflon bearings for 20 seconds at 25,000 rpm. The homogenate was added to a glass centrifuge tube, fifteen ml of acetone was added, and the sample was homogenized in the polytron for 20 seconds. The supernatent was drawn off into a separatory funnel containing 150 ml of deionized water that had been preextracted with freon. This polytron extraction was repeated once more with 15 ml of acetone and then twice using 25 ml of freon each time. The supernatents from each of these extractions were also added to the separatory funnel. The funnel was shaken, and then the freon was drawn off. This was repeated two more times using 50 ml of freon each time, and the freon extracts were combined.

The extract was then passed through a cleanup column. This column consisted of a 2 x 25 cm (50g) column of BioSil A silicic acid (100-200 mesh, BioRad) that was fully activated by heating at 120°C for 6 hours and the column was prerinsed with 100 ml of methylene chloride and then 100 ml of freon. The sample extract was added to the column at full volume (no volume reduction), and helium pressure was used to increase the flow rate. After the sample level had reached the top of the column, 25 ml of freon and then 50 ml of methylene chloride 9 was added to and eluted from the column. All of the column eluent was collected in a round bottom flask. This extract was then volume reduced in a round

bottom flask using a heating mantle and a Kuderna-Danish evaporator and 3-ball Snyder column. The sample was solvent exchanged into about 5 ml of hexane and transferred to a 10 ml concentrator tube fitted with a micro-Snyder column and then volume reduced to 1 ml in a tube heater.

The sample extract was added to a separation column in 1 ml of hexane. The column was a 0.9 x 45 cm (11.5 g) column of BioSil A silicic acid (100200 mesh) that had been activated and then 5% deactivated with water. Before samples were added, the column was cleaned with 50 ml of methylene chloride and 50 ml of pentane. The first fraction (f1) was eluted from the column with 50 ml of pentane. The second fraction (f2) was 35 ml of 20% methylene chloride in pentane. Each fraction was volume reduced as described above.

The f1 fractions were analyzed by electron capture glass capillary gas chromatography for PCBs and HCB. The f2 fractions were analysed for polycyclic aromatic hydrocarbons (PAHs) by gas chromatography-mass spectrometry (GCMS).

For the PCB and HCB analyses, 1 ul of each sample was injected splitless into a Hewlett Packard 5840 gas chromatograph equipped with an electron capture detector and a 30m DB-5 fused silica capillary column (J + W Scientific). Helium was used as the carrier gas, and the oven temperature was held at 80°C for 4 min and then 10 programmed from 80 to 290°C at 10°C/min. The injector temperature was 270°C, and the detector was maintained at 300°C.

PCB concentrations were calculated as Aroclor 1254. The samples were quantified by comparing the heights of 7 peaks in the sample chromatograms to those of the same peaks in standards of Aroclor 1254

that were analysed at the beginning and end of each day. Similar methods were used for HCB quantification using an authentic standard of this compound.

The f2 fractions were analyzed for selected PAHs and associated compounds using a Finnigan 4531 quadrupole Gas Chromatograph-Mass Spectrometer (GCMS). The GC was operated with a capillary column in the splitless injection mode. Each injection consisted of approximately 1 microliter of sample extract and about two microliters of solvent backflush. The split flow was approximately 50 ml/min and the septum sweep flow was approximately 2 ml/min. Both flows were suspended for 1 minute just before the time of injection. The DB-5 fused silica column was 30 meters in length with a bore of .25mm and a film thickness of .25 microns. The GC oven was held at an initial temperature of 50°C for 2 minutes, ramped to 330°C at 10°C/min and held there for an additional 9 minutes.

The last 40 cm of the column passed through the transfer line oven area, which was heated to 300°C, and then to within 1 cm of the source volume in the source area of the MS, which was maintained at 150°C. The source was operated in the electron impact mode at 70° electron volts. The filament emission current was 200 microamps and the various source potentials were adjusted to produce a spectrum of Decafluorotriphenylphosphine (DFTPP) which would meet the specifications detailed by Eichelberger et.al.(1975).

Quantitation with the GCMS involved using the data system to measure the areas of selected peaks using extracted ion current profiles (EICPs) and internal injection standards (IISs). The two IISs, monofluorobiphenyl and monofluorofluoranthene, were added to the sample extracts just prior to the injection. The standards solution also contained these two IISs.

A spike and recovery study was conducted in order to check the recovery of HCB using our analysis procedures. The procedures were developed for the analysis of PCBs and PAHs and show good recoveries (80-90%) for these compounds. However, the methods had not been previously checked for HCB recovery. For this study, HCB was spiked into 3 samples of a standard mussel homogenate that has been extensively analysed as part of U.S. Mussel Watch intercalibration exercises (Galloway et al., 1983). The spike level was about 5 ng/g dry weight. A homogenate sample with no spike added and a blank analysis was also conducted along with this set of samples.

The recovery results shown in Table 1 indicate that the mean HCB percent recovery was 56.4 $\pm$ 9.04. No HCB or interfering peaks were found in the homogenate sample with no spike added or in the blank. Blank analyses were also conducted with each set of sample (usually about 5-6 samples). HCB was not detected in these samples. The detection limit for these methods was about 1 ng/g dry weight. This is based on the average amount of sample that was extracted and our instrumental detection limits.

RESULTS

Mussels were deployed in cages for 30-35 days according to methods detailed in Phelps and Galloway (1980) at three northeast U.S. coastal locations (Narragansett Bay, Long Island Sound and New York Bight). Upon collection they were initially analyzed for PCBs and PAHs. At each location mussels were deployed, collected and analyzed from both "reference" and "contaminated" stations. Mussels from both the upper

and lower portions of Narragansett Bay were analyzed. The upper bay is heavily urbanized and industrialized and receives large contaminant inputs from sewage, urban runoff and industrial effluents. The lower portion of the bay is less densely populated and not heavily industrialized. Therefore, the anthropogenic inputs to this area are much less. The Long Island Sound mussels were deployed at a reference site and at an experimental dredge material disposal site as part of a cooperative program between EPA and the U.S. Army Corps of Engineers. The program is know as the Field Verification Program (FVP). These organisms were collected about two months after the experimental dredging operation was completed. Mussels were deployed also at Jones Beach, New York, which was designated as a reference station, and immediately outside a boundary of the New York Bight sewage sludge disposal area, the contaminated site.

Table 2 shows the results of the chemical analyses of the mussel samples. PCB concentrations (measured as Aroclor 1254) were generally highest in the upper Narragansett Bay organisms. Long Island Sound has lower levels and the New York Bight organisms contained the lowest concentrations. At all three locations the PCB concentrations in the mussels from the contaminated stations were generally higher than those in the reference organisms.

PAH analyses were conducted on samples from Narragansett Bay and Long Island Sound. We report here the concentrations of three of the more prominent compounds in the samples. These are the three ring compound phenanthrene, pyrene which is a four ring compounds and the five ring compound benzo(a)pyrene. The concentrations of phenanthrene and pyrene were similar for the Narragansett Bay and Long Island Sound

mussels. However, benzo(a)pyrene concentrations were higher in the Long Island Sound samples. As with the PCBs, the mussels from the contaminated locations had higher PAH concentrations than those from the reference site.

Archived extracts of mussels from the three locations were recently analyzed for HCB. However, this compound was below the detection limit (< 1 ng/g dry weight) in all of the mussel samples analyzed. Figure 8 shows electron capture gas chromatograms of (a) an HCB authentic standard as well as a sample analyzed using two different instrumental settings. The settings for the first (b) were chosen to keep the PCB peaks on scale. The second (c) was run at a very sensitive setting in order to look at compounds at lower concentration in the extract. This chromatogram indicates the presence of a peak which coelutes with the HCB standard and this is typical of what was found for most of the samples. However, we were unable to confirm the presence of HCB in the samples by GC/MS. If HCB exists in these extracts it could only be present in extremely low concentrations which are below our detection limits. Chromatograms of seawater (dissolved and particulate phases) and sediments also reveal very low levels of HCB.

DISCUSSION

The n-octanol/water partition coeficient (Kow) for HCB is about 5.50; therefore, HCB would be expected to bioconcentrate to high levels (Chiou, 1985). Konemann and van Leeuwen (1980) found that HCB showed a

bioconcentration factor of 1.6×10^5 in guppies. However, Oliver and Niimi (1983) reported that the HCB bioconcentration factor for rainbow trout exposed for 119 days was considerably lower than expected when compared with other compounds with similar Kow values. They concluded that it takes a very long time for this compound to come to equilibrium in aquatic organisms and that the fish concentrations were not at equilibrium.

Therefore, it is possible that the mussel exposures used for this study were too short for significant concentrations of this compound to have accumulated, although we believe that this is unlikely. It is also possible that HCB is not taken up by mussels because of steric factors or simply that the concentrations were very low in the study areas. In any case, it appears that the concentrations of this compound in mussels from coastal areas of the Northeastern U.S. are low relative to the concentrations of other organic contaminants such as PCBs and PAHs.

The specific subject of this paper is HCB in the marine environment as seen through the analysis of archived biomonitoring data and samples. However, the approach is offered as a generic one. In that sense, HCB is the first in a series of compounds that may be identified, a priori, and then evaluated in this manner in the marine environment. The goal is to answer the question as to whether or not the environmental perspective indicates a problem great enough to require the expenditure of additional monitoring resources. In the case of HCB, especially as compared to marine environmental levels of PCBs and PAH, the answer is no. The marine environment does not appear to provide a significant route of entry for HCB to man.

Future efforts in the development of biomonitoring data bases and archived materials include plans to identify peaks that consistently occur around ocean dumpsites, but which have not been identified as yet. Techniques for standardizing the acquisition of data from CCMS analyses on to computer tapes so that existing software for identification of such peaks may be meaningfully utilized are being considered. The goal will be to archive taped output in a standardized form for subsequent use.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Clifford Katz and William Nelson for their critical review of the manuscript. We also thank Robert Bowen, Adria Elskus, Lawrence LeBlanc, Richard McKinney, Curtis Norwood, and Sharon Pavignano for their contributions to this work.

REFERENCES

Chiou, C.T. 1985. Partition coeficients of organic compounds in lipid-water systems and correlations with fish bioconcentration facoors. Environmental Science and Technology 19: 57-62.

Eichelberger, J.W., L.E. Harris and W.L. Budde. 1975. Chromatography-mass spectrometry systems. Analytical Chemistry 47: 995-1000.

Farrington, J.W.; Goldberg, E.D.; Risebrough, R.W.; Martin, J.H.; and V.T. Bowen. 1983. U.S. "Mussel Watch" 1976-1978: An Overview of the Trace-Metal, DDE, PCB, Hydrocarbon, and Artificial Radionuclide Data. Environmental Science and Technology 17: No. 8. 490-496.

Galloway, W.B., J.L. Lake, D.K. Phelps, P.F. Rogerson, V.T. Bowen, J.W. Farrington, E.D. Goldberg, J.L. Lasiter, G.C. Lawler, J.H. Martin and R.W. Risebrough. 1983. The Mussel Watch: Intercomparison of trace level constituent determinations. Environmental Toxicology and Chemistry 2: 395-410.

Goldberg, E.D.; Bowen, V.T..; Farrington, J.W.; Harvey, G.R.; Martin, J.H.; Parker, P.L.; Risebrough, R.W.; Roberston, W.E.; Schneider, E.; Gamble, E. 1978. The Mussel Watch. Environmental Conservation. 5, 101-125

Konemann, H. and K. van Leeuven. 1980. Toxicokinetics in fish: Accumulation and elimination of six chlorobenzenes by guppies. Chemosphere 9: 3-19.

Oliver, B.G. and A.J. Niimi. 1983. Bioconcentration of chlorobenzenes from water by rainbow trout: Correlations with partition coefficients and environmental residues. Environmental Science and Technology 17: 287-291.

Phelps, D.K.; and W.B.Galloway. 1980. A Report on the Coastal Environmental Assessment Stations (CEAS) Program. In: Rapp. P.-v. Reun. Cons. int. Explor, Mer, 179: 76-81.

Phelps, D.K.; Reynolds, B.H.; Galloway, W.B.; Scott, K.J.; and C.H. Katz. Evaluation of Marine Monitoring Techniques for Coastal Disposal of Waste Material. 1985 ASTM special publication. in prep.

Reynolds, B.H.; Barszcz, C.A.; Phelps, D.K.; and J. Heltshe. 1981. International Council for the Exploration of the Seas. Statuatory Meeting. Woods Hole, Massachusetts, USA, C.M. 1981/E:25.

Yevich, P.P.; and C.A. Barszcz. 1983. Histopathology as a monitor for marine pollution. Results of the histopathologic examination of the animals collected for the U.S. 1976 Mussel Watch Program. Conseil International L'exploration de la Mer, Rapports et Proces-Verbaux Vol. 182: 96-102.

Table 1. Spike and recovery results for HCB added to a mussel homogenate at a level of 5 ng/g dry weight.

	% Recovery	Mean ± S.D.
Sample 1	56.4	
Sample 2	48.4	56.4 ± 9.04
Sample 3	66.2	

Table 2. HCB, PCB and selected PAH concentrations in transplanted mussels (ng/g dry weight).

	HCB	PCBs*	Phenanthrene	Pyrene	Benzo(a)pyrene
NARRAGANSETT BAY					
Upper Bay 1	n.d.	1640	2.74	60.9	18.3
Upper Bay 2	n.d.	1160	3.89	84.3	4.11
Upper Bay 3	n.d.	1067	4.54	91.1	5.50
Lower Bay 1	n.d.	349	5.99	20.5	2.90
Lower Bay 2	n.d.	391	4.28	16.5	1.52
Lower Bay 3	n.d.	354	2.56	8.94	0.71
LONG ISLAND SOUND					
FVP Dumpsite 1	n.d.	584	11.9	84.8	34.5
FVP Dumpsite 2	n.d.	774	10.6	87.5	42.6
FVP Dumpsite 3	n.d.	743	10.9	88.7	42.2
Reference 1	n.d.	582	8.17	39.5	28.2
Reference 2	n.d.	421	6.83	29.5	20.1
Reference 3	n.d.	429	7.05	27.1	11.1
NEW YORK BIGHT					
Sewage Dumpsite 1	n.d.	216	n.a.	n.a.	n.a.
Sewage Dumpsite 2	n.d.	257	n.a.	n.a.	n.a.
Sewage Dumpsite 3	n.d.	324	n.a.	n.a.	n.a.
Jones Beach 1	n.d.	165	n.a.	n.a.	n.a.
Jones Beach 2	n.d.	145	n.a.	n.a.	n.a.
Jones Beach 3	n.d.	101	n.a.	n.a.	n.a.

* Quantified as Aroclor 1254
n.d. - not detected
n.a. - not analysed

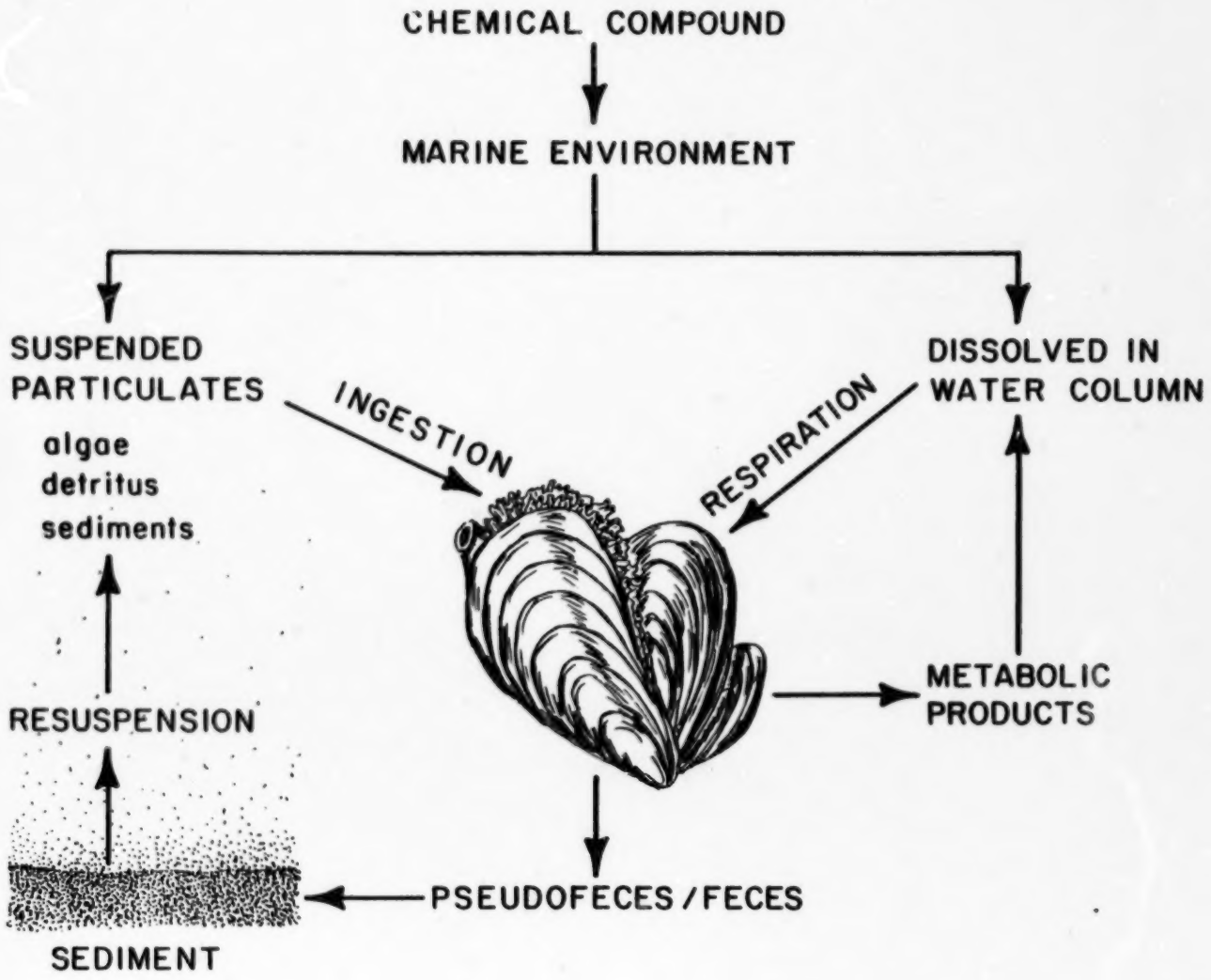


Figure 1. Chemical pathways through the marine environment to the mussel, Mytilus edulis.

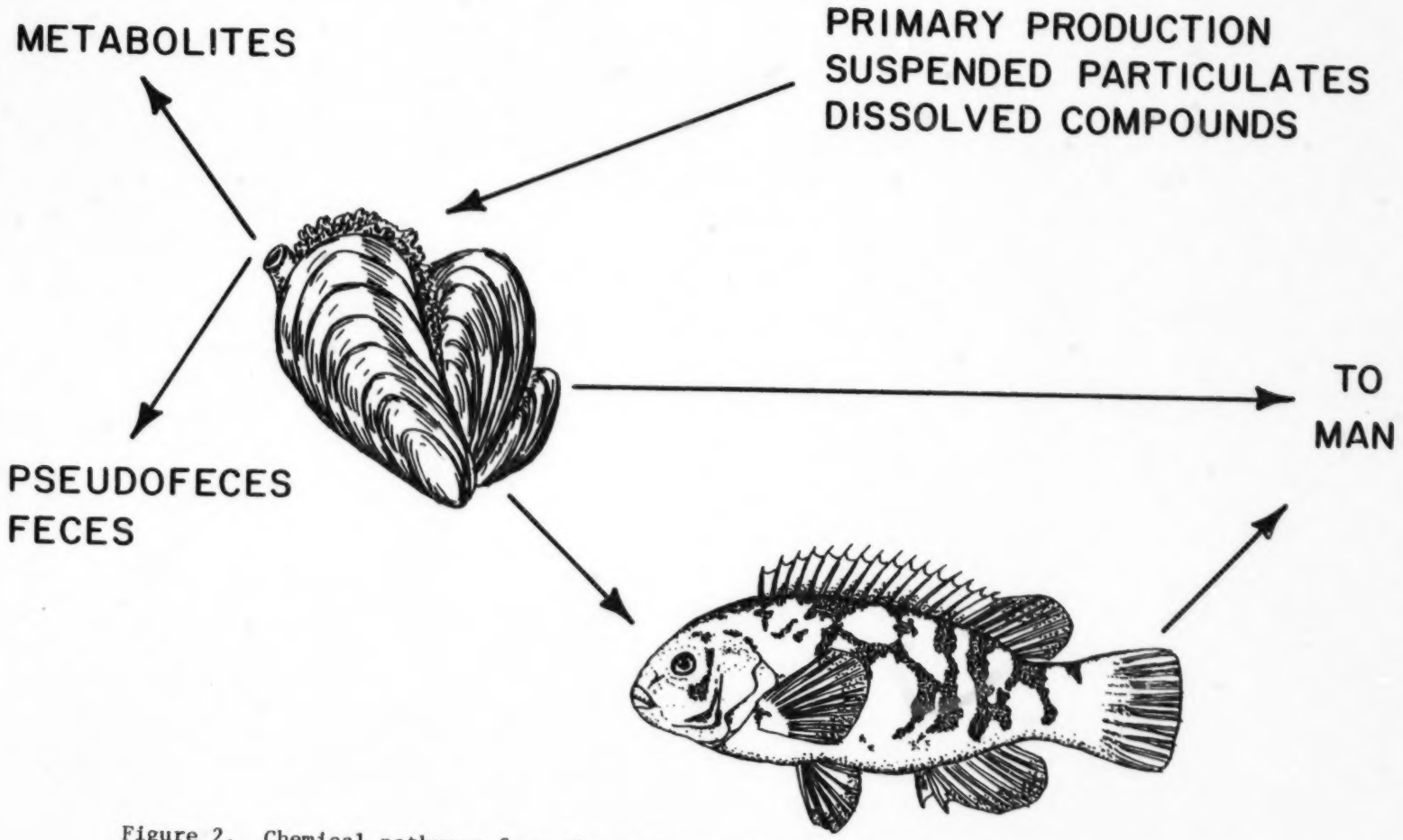


Figure 2. Chemical pathways from the marine environment through the mussel to man.

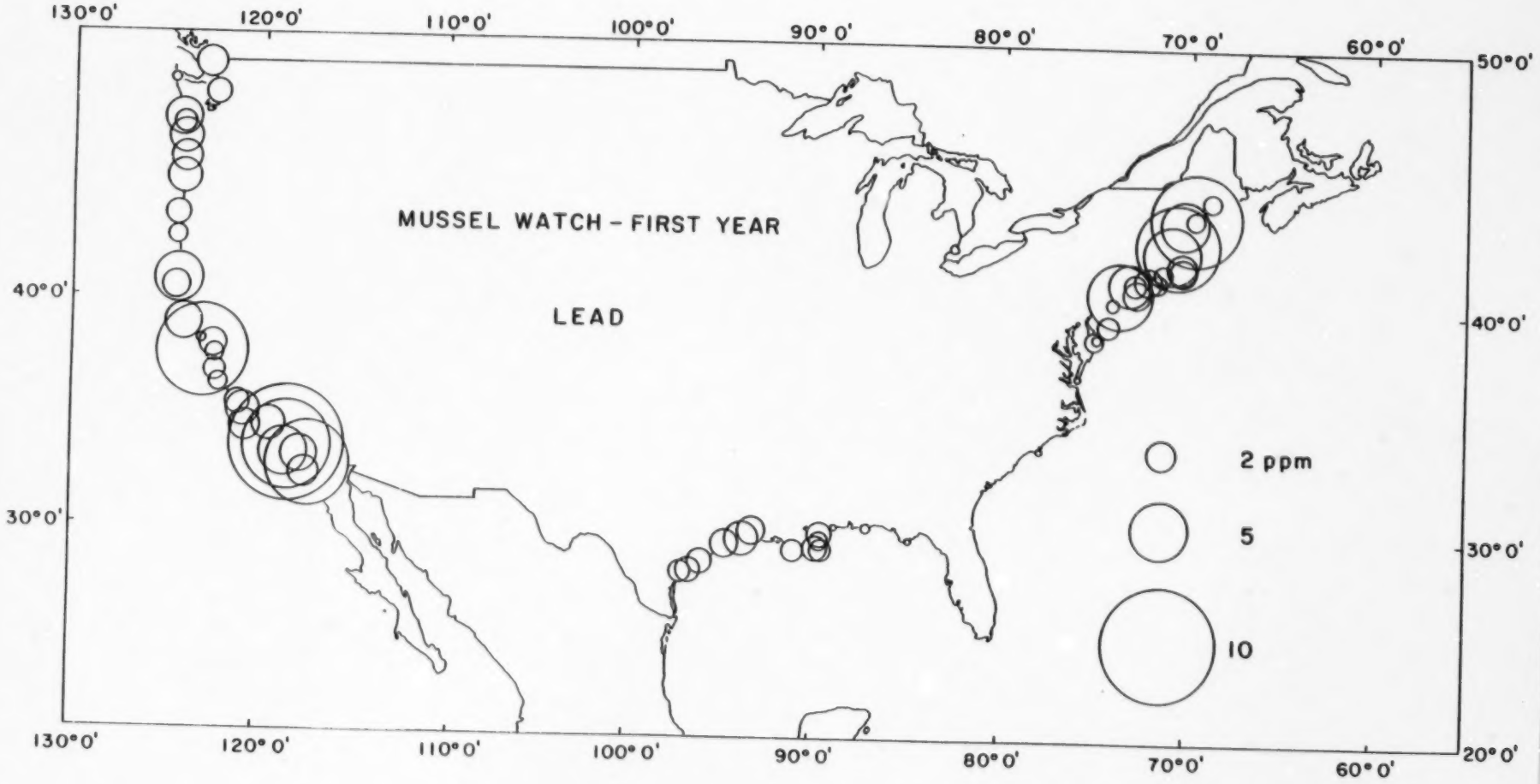


Figure 3. Distribution of lead in mussel tissues collected from the coastal U.S. during the U.S. Mussel Watch program.

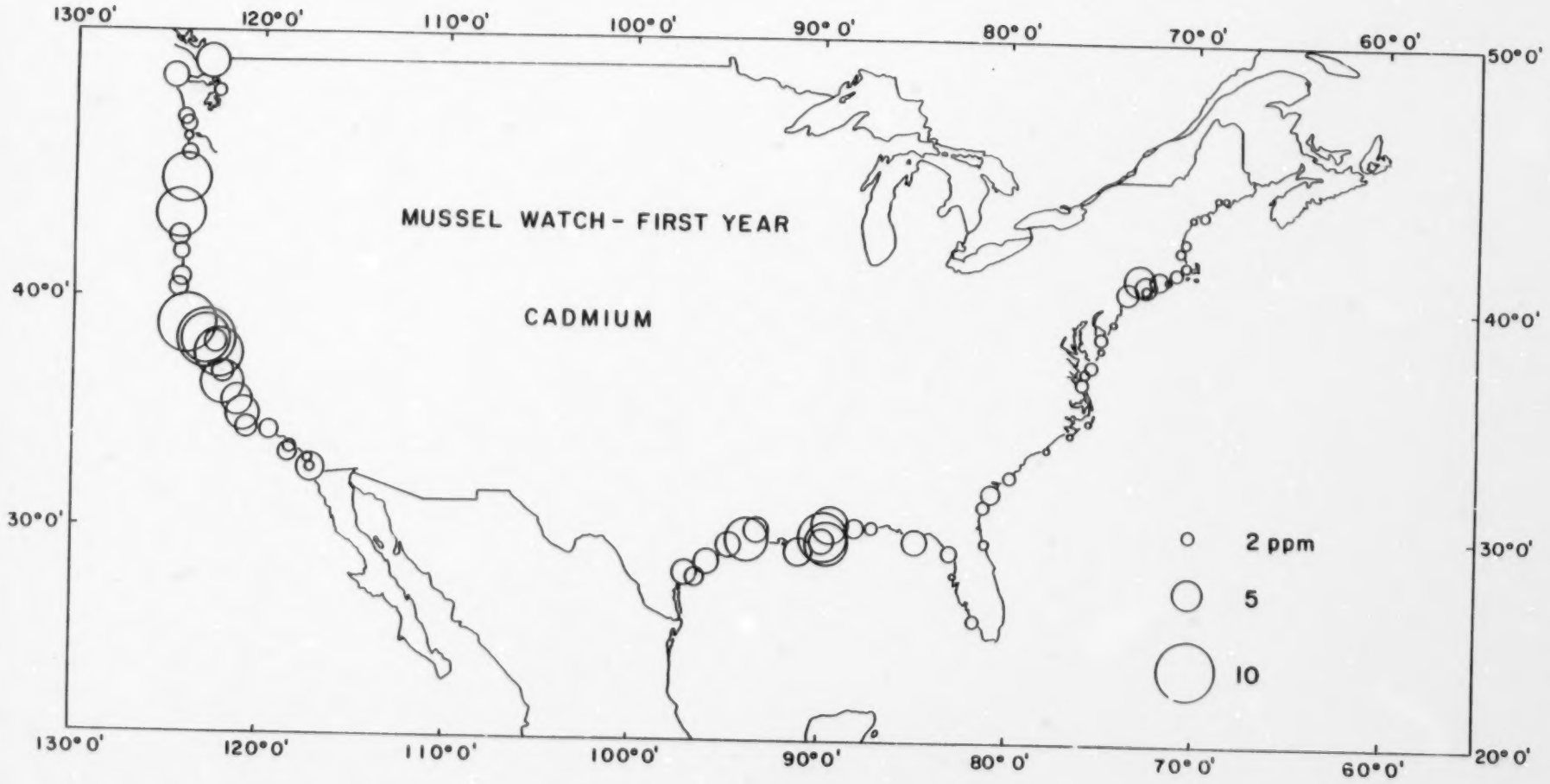


Figure 4. Distribution of cadmium in mussel tissues collected from the coastal U.S. during the U.S. Mussel Watch Program.

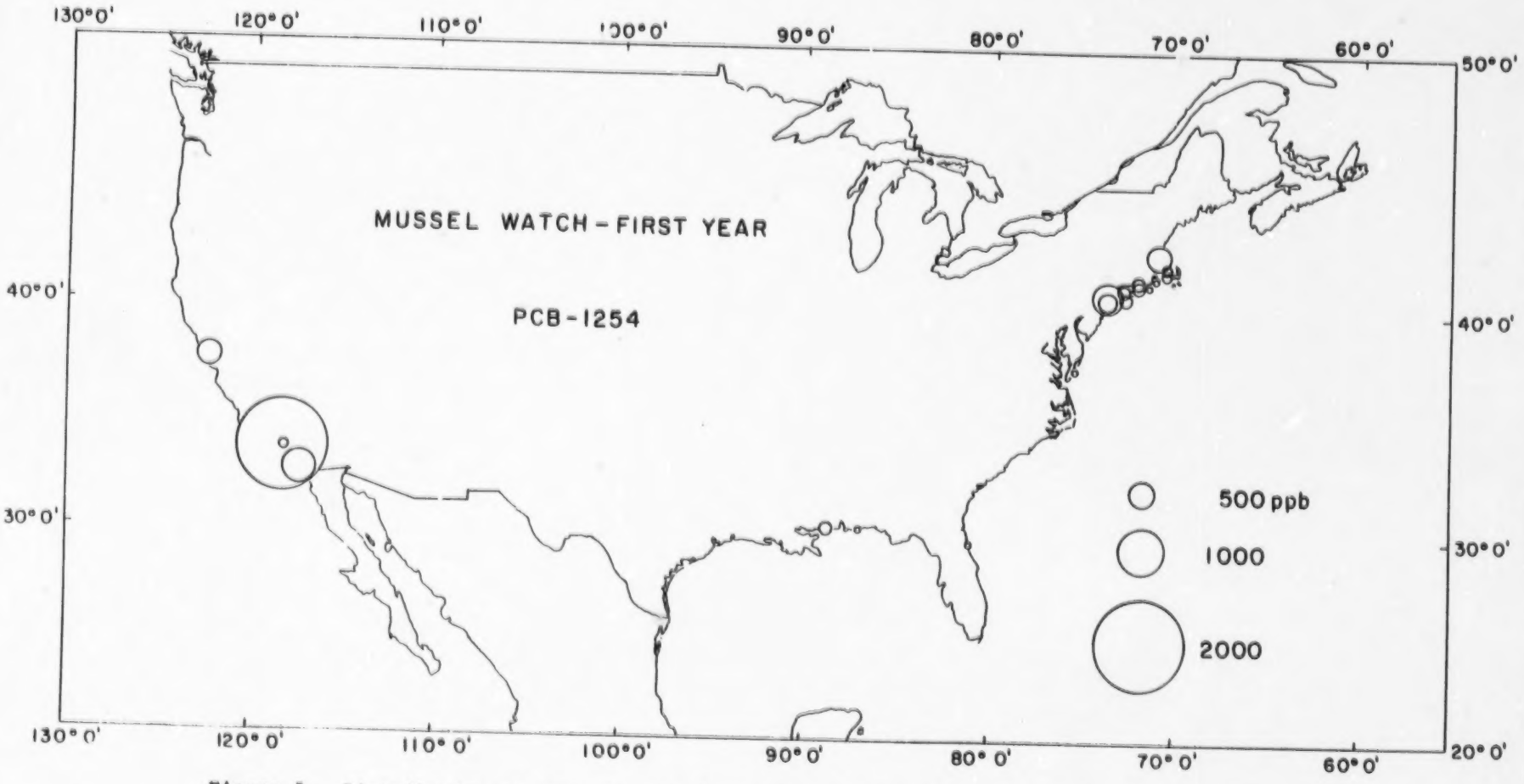
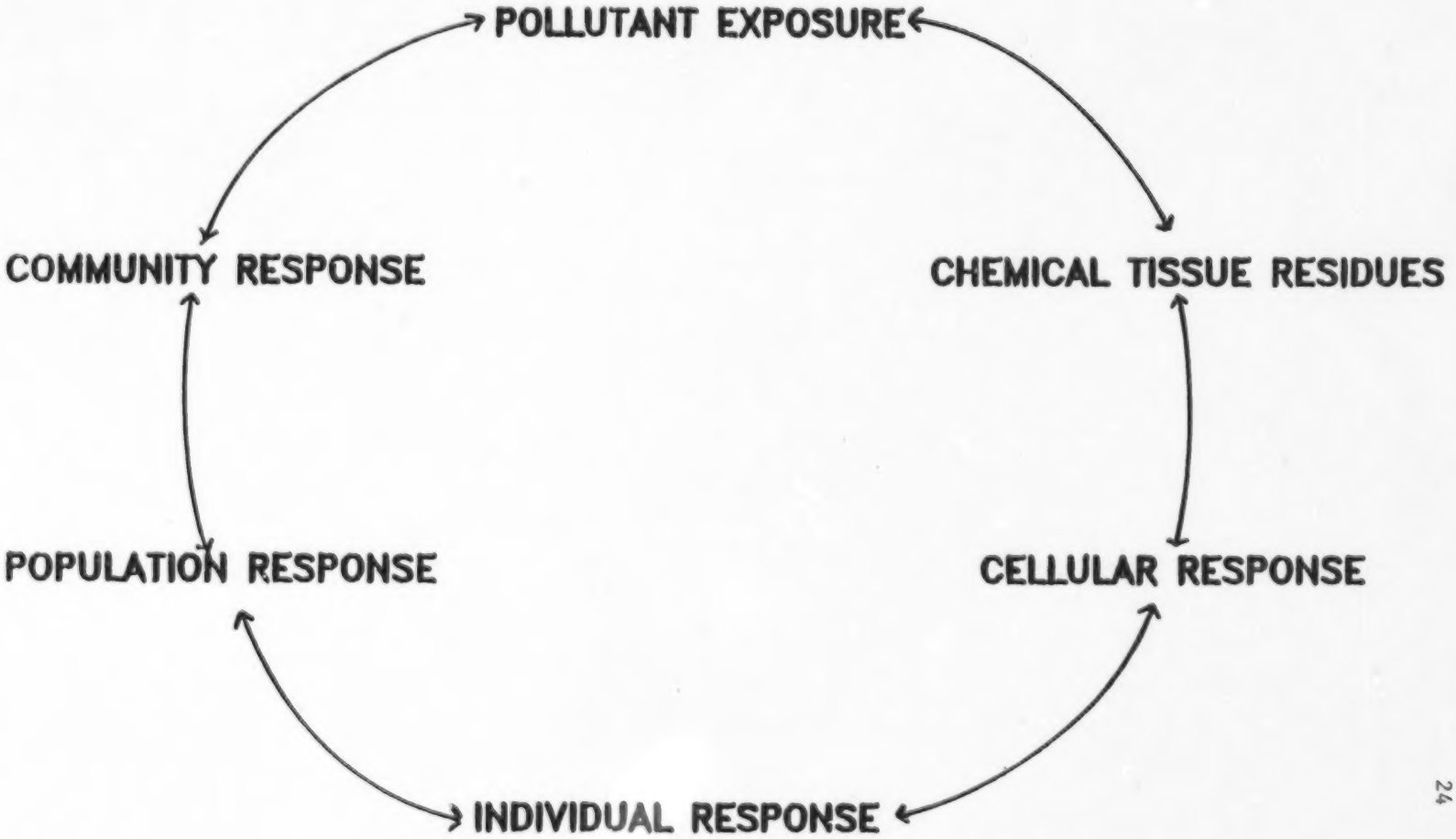


Figure 5. Distribution of PCBs in mussel tissues collected from the coastal U.S. during the U.S. Mussel Watch program.

NATIONAL MUSSEL WATCH PROGRAM

Figure 6. Levels of biological organization used in developing effects methods in the U.S. Mussel Watch program.



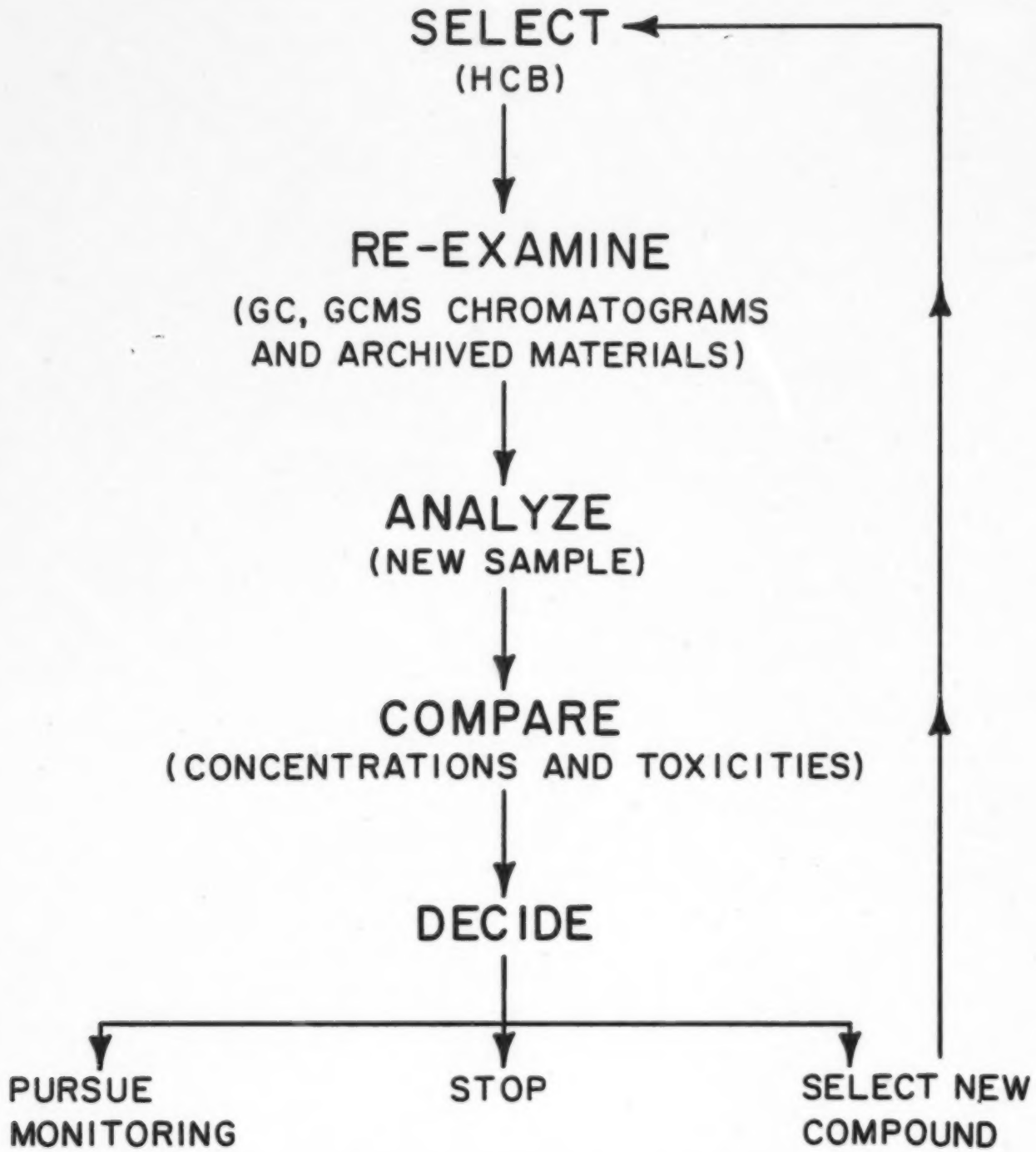


Figure 7. Schematic presentation for the proactive use of existing mussel watch data and archived materials.

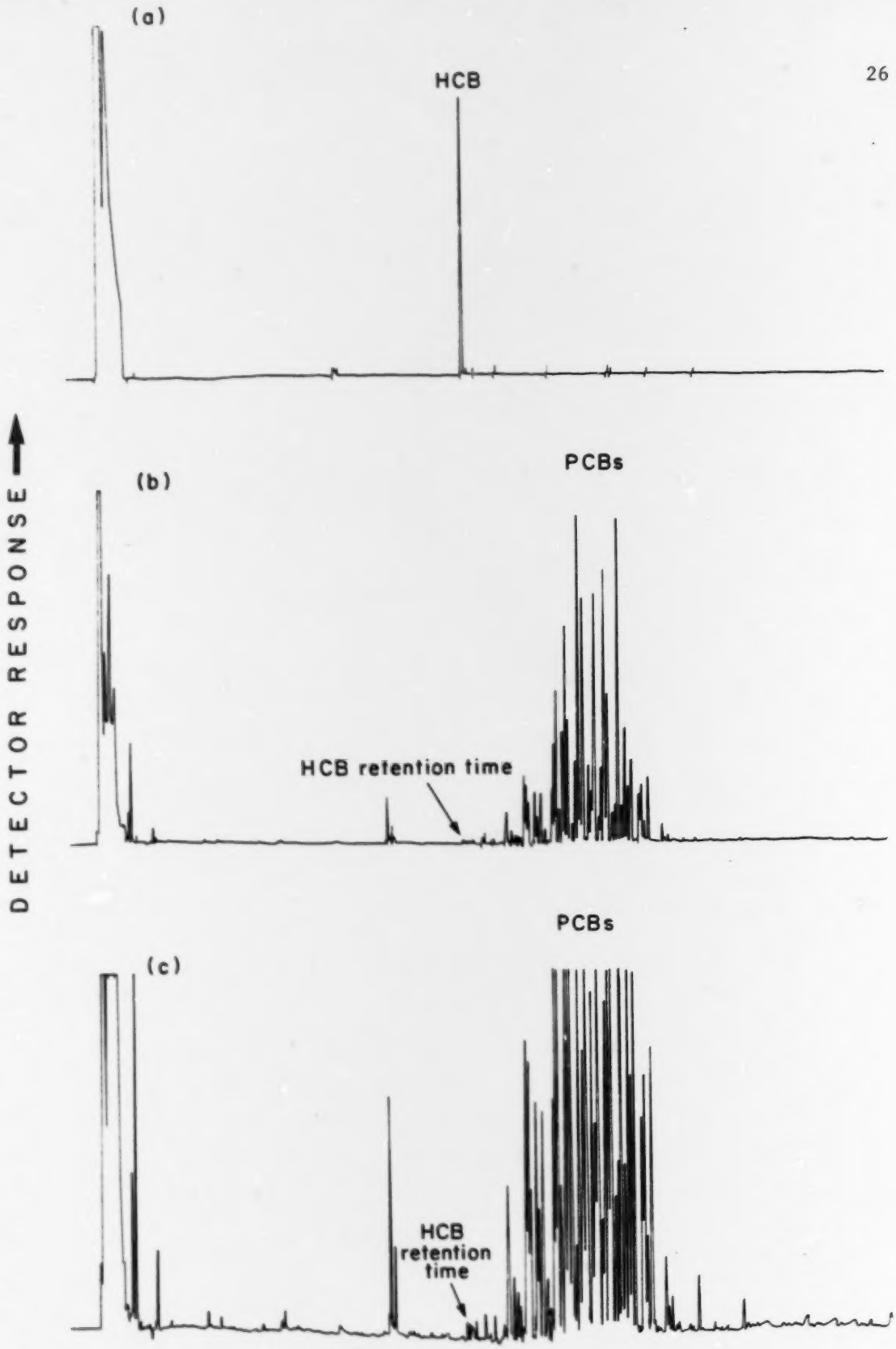


Figure 8. Chromatograms showing HCB in a spiked mussel sample (a), at the scale usually used for PCBs (b), and an expanded scale used to demonstrate peak that coelutes with the HCB spike.